UNITED STATES PATENT APPLICATION

of

BRUCE S. MCLEAN

and

VASILIY NOSOV

for

OPTICAL LENS USED TO FOCUS LED LIGHT

WORKMAN, NYDEGGER & SEELEY
A PROFESSIONAL CORPORATION
ATTORNEYS AT LAW
1000 EAGLE GATE TOWER
60 EAST SOUTH TEMPLE
SALT LAKE CITY, UTAH 84111

BACKGROUND OF THE INVENTION

1. The Field of the Invention

[01] The present invention generally relates to the field of light curing devices and, more specifically, to light curing dental devices and methods for irradiating and curing photosensitive dental filling compounds.

2. The Relevant Technology

[02] In the field of dentistry, dental cavities are often filled and/or sealed with photosensitive compounds that are cured by exposure to radiant energy, such as visible light. These compounds, commonly referred to as light-curable compounds, are placed within dental cavity preparations or onto dental surfaces where they are subsequently irradiated by light. The radiated light causes photosensitive components within the compounds to polymerize, thereby hardening the light-curable compounds within the dental cavity preparation or another desired location.

[03] Light is typically directed to the light-curable compounds by a light-generating dental device comprising a lamp, such as a halogen lamp bulb, and a light guide, such as a fiber optic wand that can capture some of the light that is generated by the lamp. Special reflectors and filters are typically employed to control the quantity and wavelength of light that is permitted to enter the fiber optic wand. Light traveling through the fiber optic wand is finally dispersed out of a tip at a desired location within a patient's mouth.

[04] One problem with existing LED light-generating devices, as well as with other light-generating devices which incorporate lamps, is they require a fiber optic wand to carry the light emitted by the lamp from within the light-generating device to the application site where the light is finally directed to a desired location. Light-generating devices may be

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manufactured with integrated fiber optic wands or sold with separate and detachable fiber optic wands. Although fiber optic wands are useful for their intended purposes, they are undesirable because they add to the cost of equipment, and hence to the total cost for performing dental procedures with light-curable compounds

[05] Another problem with existing light-generating devices is that they are not very efficient. In particular, a large quantity of radiation energy is lost due to filtering, dissipated light, and light that is not reflected and properly channeled into the fiber optic wand. This is a problem because it generally results in increased power requirements for generating a desired output of radiation. Another problem is that complicated cooling systems are required to compensate for the heat that is generated by unchanneled and unused light, such as the light that is absorbed by special filters, reflective surfaces, and shields.

[06] In an attempt to overcome these aforementioned problems, some light-generating devices have been manufactured with alternative light generating sources, such as light-emitting diodes (LEDs) which may be configured to radiate light at only desired wavelengths, thereby eliminating the need for special filters and generally reducing the amount of input power required to generate a desired output of radiation.

[07] LEDs, however, emit light at a wide angle of dispersion, about 120°, which makes it difficult to focus the radiated light into the fiber optic wand. In order to capture the widely dispersed light, existing LED light-generating devices typically comprise special focusing reflectors and complicated designs that are required for housing the reflectors.

[08] Yet another problem with existing devices is that they are not able to properly focus the light that is emitted from the LED or other light-generating source once it is directed out of the fiber optic wand. This is a problem because light emitted out of the fiber optic wand

may create problems when it irradiates sensitive mouth tissues. Accordingly, it is desirable to focus the light only onto the light-curable compounds. Focusing the light onto the light-curable compounds can also be beneficial for reducing the duration of irradiation that is required to cure the light-curable compounds.

[09] Accordingly, in view of the foregoing, there is currently a need in the art for improved devices for focusing light from light-generating sources for curing light-curable compounds during dental procedures.

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SUMMARY OF PRESENTLY PREFERRED EMBODIMENTS

[010] Briefly summarized, presently preferred embodiments of the present invention are directed to optical devices for focusing light which is directly emitted from light-generating sources of dental instruments for curing light-curable compounds.

[011] According to one presently preferred embodiment, the optical devices of the invention comprise an aspheric lens and a transparent shield. The aspheric lens comprises a first end that is substantially flat and a second end that is curved. The curvature of this second end may comprise a hyperbolic curvature or an elliptical curvature and is configured for focusing light into a predetermined focus of illumination. According to another embodiment, the lens may comprise a hemispheric lens with a first end that is substantially flat and a second end comprising a hemispheric curvature.

[012] According to the invention, the aspheric lens is configured to focus light emitting from a light-generating source such as a light-emitting diode (LED) of a light-generating dental device. The LED is preferably affixed to the end of an extension arm extending away from the light-generating dental device. The transparent shield, which is removably attachable to the extension arm, protects the aspheric lens from physical contact during use. The aspheric lens, according to one embodiment, is held securely in place by the transparent shield, with the flat end of the aspheric lens facing the LED and in close proximity to the LED.

[013] The transparent shield is removably attachable to the extension arm by ridges and/or grooves that correspondently mate with ridges and/or grooves of the extension arm. The transparent shield is composed of a material composition that is suitable transparent for enabling light to pass therethrough. It will also be appreciated that the lens is composed of a

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material composition which is transparent. Suitable transparent materials for the lens and transparent shield include, but are not limited to, glass, aluminum dioxide, sapphire quartz, acrylic, polyacrylic, polypropylene and silicone.

[014] According to one embodiment, the transparent shield comprises a conical shape having an apex, which may be used during the dental procedures to manipulate and press the light-curable compounds into a desired placement. After the dental procedure is completed, the transparent shield may be removed and replaced with a new transparent shield.

[015] In some embodiments, in which the aspheric lens is composed of relatively inexpensive materials, such as common plastics, it may be desirable for the aspheric lens to be affixed to the transparent shield so that both the transparent shield and the aspheric lens may be replaced after use. In other embodiments, however, such as when the lens is composed of more expensive material compositions such as optical quartz, it may be desirable to affix the lens to the extension arm so that the transparent shield can be replaced without having to also replace the lens. When the lens is held in place by the extension arm, as well as with the other embodiments described herein, the optical devices of the invention may be broadly construed to include the extension arm and LED.

[016] During use the LED emits light that is captured by the aspheric lens as a result of the proximity in which the aspheric lens is placed next to the LED. The light passing through the aspheric lens is focused by the aspheric lens into a desired focus of illumination that is desirable for polymerizing light-curable compounds while performing Class II dental restorations. According to one embodiment, the desired focus of illumination comprises a diameter of about 8 mm at a distance of about 3-5 mm from the apex of the transparent

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shield and about 3-10 mm away from the aspheric lens. However, the dimensions of the desired focus of illumination, or footprint, may vary to suit different needs and preferences.

[017] It will be appreciated that one benefit of the invention is that the optical devices of the invention generally focus the light into a desired focus of illumination for irradiating Class II fillings. The optical devices of the invention also generally eliminate the need for fiber optic wands to direct the light from light-generating sources from within dental instruments to desired application sites. Yet another benefit of the invention is that it generally minimizes the loss of radiation energy due to filtering systems and dissipation, which occurs when light is not properly reflected and channeled into the fiber optic wand. It will be appreciated that these are improvements over the prior art light-generating dental devices currently used for curing light-curable compounds during dental procedures.

[018] These and other benefits, advantages and features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[019] In order that the manner in which the above recited and other benefits, advantages and features of the invention are obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[020] Figure 1 illustrates a partial cross-sectional side view of one embodiment of a dental instrument that includes an extension arm with an LED and an optical device attached to the extension arm proximate the LED which includes an aspheric lens and a transparent shield;

[021] Figure 2 illustrates a perspective view of one embodiment of the optical device of the invention that includes an aspheric lens and a transparent shield;

[022] Figure 3 illustrates a partial cross-sectional view of one embodiment of the optical device of the invention which includes an aspheric lens held securely in place by a transparent shield which is removably attachable to an extension arm having an LED in such a manner that the flat end of the aspheric lens is held facing and proximate the LED;

[023] Figure 4 illustrates a partial cross-sectional side view of one embodiment of the invention which includes a hemispheric lens held securely in place by a transparent shield which is removably attachable to an extension arm having an LED in such a manner that the flat end of the aspheric lens is held facing and proximate the LED;

[024] Figure 5 illustrates a partial cross-sectional side view of one alternative embodiment of the optical device of the invention which includes an LED and an extension arm securely

holding an aspheric lens in place, with a flat end of the aspheric lens facing and proximate the LED, and a transparent shield removably attachable to the end of the extension arm; and

[025] Figure 6 illustrates one embodiment of the optical device of the invention and a cross-sectional view of a tooth, in which the transparent shield is conical having an apex which is inserted within the dental cavity preparation of a tooth, and in which light is being directed onto a light-curable compound within the dental cavity preparation.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[026] A detailed description of the optical devices of the invention will now be provided with specific reference to figures illustrating various embodiments of the optical devices. It will be appreciated that like structures will be provided with like reference designations.

[027] Reference is first made to Figure 1, which illustrates a partial cross-sectional view of one preferred embodiment of an optical device 10 of the invention. As shown, the optical device 10 is fixedly attached to an extension arm 12, which extends between optical device 10 and a dental instrument 14.

[028] Dental instrument 14 may comprise any dental instrument or other device that is configured for generating light with a suitable wavelength for curing light-curable compounds, preferably within the range of about 400 nanometers to about 500 nanometers. According to one preferred embodiment, dental instrument 14 operates by supplying power to a light-emitting diode, such as LED 16. When LED 16 receives power supplied by dental instrument 14 then light, which is suitable for curing light-curable compounds, is generated and emitted by LED 16.

[029] One problem with existing dental instruments is that the LED or other light-generating source is typically housed within the main body of the dental instrument, thereby requiring a fiber optic light wand to channel the light from the dental instrument to the dental application site where the light-curable compounds are located. This is a problem because the fiber optic light wand is unable to capture much of the light that is emitted from the LED. The light that is not captured increases the heat in the dental instrument and thus requires intricate cooling systems and devices to prevent overheating of the dental instrument. To overcome this problem, the present invention provides an optical device 10

which captures light at a remote location, away from the main body of the dental instrument 14, at the end of an extension arm 12, as shown. According to this embodiment, LED 16 generates light at the end of the extension arm 12, away from the main body of the dental instrument 14. It will be appreciated that separating LED 16 away from the main body of the dental instrument 14 is useful for minimizing the heat that is generated within the main body of dental instrument 14. Separating the light guide 10 away from the body of the dental instrument 14 is also ergonomically useful for enabling the dental practitioner to place the tip of the light guide 10 into the mouth of the patient during dental procedures.

[030] Another problem with prior art devices is that they are not able to properly focus the light that is emitted from the LED or other light-generating source once it is emitted by the light-generating source. This is a problem because unfocused light might irradiate and thereby irritate sensitive mouth tissues. Unfocused light can also increase the duration of time that is required to cure the light-curable compounds. The present invention overcomes these problems by providing an optical device 10 that is configured for focusing the light emitted by the light-generating source into a desired focus of illumination, as described herein.

[031] Turning to Figure 2, it is shown that optical device 10 of the invention includes a lens 20 and a transparent shield 22. The lens 20 and the transparent shield 22 are preferably composed of a transparent material so as to enable light to pass therethrough. Suitable transparent materials include, but are not limited to, glass, aluminum dioxide, sapphire, quartz, acrylic, polyacrylic, polypropylene and silicone. The lens may also comprise a transilluminate lens that is color tinted for filtering out undesired radiant energy in particular color spectrums.

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[032] According to one preferred embodiment, the lens 20 is aspheric, as shown. The term "aspheric" is generally defined herein to include any curvature departing from a traditional spherical form. In particular, the term "aspheric" refers to any parabolic, hyperbolic, or ellipsoidal curvature.

[033] Turning now to Figure 3, it is shown how lens 20 comprises a first end 24 which is substantially flat and a second end 26, which is defined by a curvature. The curvature of the second end 26 is preferably aspheric comprising one of a hyperbolic curvature, a parabolic curvature, and an elliptical curvature. According to one alternative embodiment, the second end 26' of the lens 20' may also comprise a hemisphere or hemispheric curvature, as shown in Figure 4. The function of the second end of the lens is generally to focus light into a predetermined focus of illumination.

[034] According to one embodiment, optical device 10 also comprises means for securely holding the lens 20 in place so that the substantially flat first end 24 of the lens 20 is held in close proximity to, and facing, the LED 16, as shown in Figure 3. This generally causes light emitting from the LED 16 to enter the substantially flat first end 24 of the lens 20. According to one embodiment, not shown, the LED 16 is ground flat so that the lens 20 can be placed directly against the flat surface of the LED 16. This alternative embodiment is useful for causing even more of the light emitted from the LED 16 to enter the lens 20.

[035] It will be appreciated that transparent shield 22 comprises one suitable means for securely holding the lens 20 in place. In particular, the transparent shield 22 may hold the lens 20 securely in place by frictionally engaging the side surfaces of the lens 20 or alternatively the transparent shield 22 may be configured with clips 30, as shown, which

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60 EAST SOUTH TEMPLE
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wrap around and secure the lens 20 in place. The transparent shield also effectively protects the lens 20 from contact with foreign substances and materials during use.

[036] This embodiment shown in Figure 3, with lens 20 held in place by transparent shield 22, is desirable when the lens 20 is manufactured with inexpensive materials such as plastics, thereby making the optical device 10 disposable and replaceable. According to one alternative embodiment, however, lens 20 may comprise material compositions that are more expensive, such as optical quartz, in which case it may be desirable for lens 20 to be fixedly attached to or at least securely held in place by extension arm 12. Such an embodiment is illustrated in Figure 5. As shown, lens 20 is held securely in place by retaining walls 40 which extend down from extension arm 12 and which are configured for securely holding lens 20 in place. This embodiment is particularly useful for enabling the transparent shield 22 to be replaced without having to also replace the more expensive lens 20.

[037] According to one preferred embodiment, transparent shield 22 is configured to be removably attachable to extension arm 12. As a matter of illustration, and not limitation, the transparent shield 22 may comprise ridges 32 that are configured for mating with corresponding grooves 34 in the extension arm 12, as shown in Figure 3. According to another example, as shown in Figure 5, the transparent shield 22' may also comprise grooves 35 that mate with corresponding ridges 36 of the extension arm 12. According to yet another embodiment, transparent shield 22' may be removably attachable to extension arm 12 with a friction fit (not shown) or with threads (not shown) for screwing the transparent shield 22' onto corresponding threads (not shown) of the extension arm 12.

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[038] Although the previous embodiments go into some detail regarding how the transparent shield 22 or 22' may be removably attached to the extension arm 12, it will be appreciated that the transparent shield 22 or 22' may also be fixedly attached to extension arm 12. By way of example and not limitation, the transparent shield 22 or 22' may be fixedly attached to extension arm 12 by welding or with adhesives.

[039] According to embodiments in which the transparent shield 22 or 22' are fixedly attached to the extension arm 12, as well as with all other embodiments described herein, the optical device 10 may be broadly construed to include extension arm 12, as well as LED 16.

[040] According to one preferred embodiment of the invention, light dispersed from the optical device 10 is focused by the lens 20 into a desired focus of illumination that is suitable for performing Class II restorations. Class II restorations are well known by those skilled in the art of dental restorations. According to one preferred embodiment, the desired focus of illumination, or footprint cast by the light, comprises a diameter of about 8 mm at a distance of about 3 mm to about 5 mm away from the apex 44 of the conical shaped transparent shield 22. Because the spacing between the lens 20 and the apex 44 of the transparent shield 22 or 22' may vary according to different embodiments, the distance between the aspheric lens 20 and the desired focus of illumination may also vary accordingly.

[041] The distance between the second end 26 of lens 20 and the apex 44 is preferably within the range of about 3 mm to about 5 mm, such that the distance between the lens 20 and the desired focus of illumination is preferably within the range of about 3 mm and about 10 mm. It will be appreciated, however, that the dimensions and spacing of the optical device 10 may vary to accommodate various preferences and needs. For example, according

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to one alternative embodiment, which is not shown, the optical device 10 is configured so that the second end 26 of the aspheric lens 20 biases completely against the apex 44 of the transparent shield 22 or 22', with no space therebetween. This embodiment may be desirable for manufacturing purposes and for helping securely hold the lens within a desired placement.

[042] Turning now to Figure 6, it is shown how optical device 10 is configured for being inserted into the dental cavity preparation 50 of a tooth 60. Dental cavity preparation 50 may, as shown, be filled with a light-curable compound 70 that is cured when light radiation activates photosensitive components within the light-curable compounds, thereby enabling the light-curable compounds to polymerize and harden within the dental cavity preparation.

[043] During use, the tip or apex 44 of the optical device 10 is inserted into the dental cavity preparation 50, and light is emitted for curing the light-curable compound 70. According to the invention, as described above, the light is focused by the optical device 10 into a focus of illumination having a diameter of about 8 mm at a distance of about 3 mm to about 5 mm away from the apex 44, which is desirable for curing Class II dental restorations. It will be appreciated, however, that the optical devices of the invention may be configured to create a focus of illumination of any dimension, suitable for curing any type of dental restoration.

[044] Once the light-curable compound 70 has sufficiently hardened by the light that is directed out of the optical device, another layer of the light-curable compound 70 may be added to the dental cavity preparation 50 to be cured. This process may be repeated until the dental cavity preparation 50 is entirely filled.

[045] One benefit of the optical devices of the invention, as described above, is that the optical devices of the invention generally focus light into a desired focus of illumination for irradiating Class II fillings. The optical devices of the invention also generally eliminate the need for fiber optic wands to direct the light from light-generating sources from within dental instruments to desired application sites. Yet another benefit of the invention is that it generally minimizes the loss of radiation energy due to filtering systems and dissipation, which occurs when light is not properly reflected and channeled into the fiber optic wand.

[046] It will be appreciated that although specific examples have been provided above, regarding specific shapes and curvatures of the lens, the lens may comprise any desired shape for focusing light into a desired footprint.

[047] It will be appreciated that the present claimed invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative, not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed and desired to be secured by United States Letters Patent is:

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